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(54) METHOD OF AND SYSTEM FOR PATTERN GRADING

(71) We, HUGHES AIRCRAFT COMPANY, a company organized and existing under the laws of the State of Delaware, United States of America, having a principal place of business at Centinela and Teale Street, Culver City, State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to systems and methods for grading patterns and particular to those adapted for use in the apparel industry.

Pattern grading is the process whereby the geometry of a basic pattern in a specified size (typically the sample or duplicate size) are modified to produce patterns for various other sizes.

In accordance with previous methods, each pattern piece is analyzed by an operator (the grader) who determines where that piece fits in the final assembly. From this determination and based upon past experience the grader selects a number of locations on the perimeter of the piece called grade points and specifies discrete incremental moves for these points for all of the required sizes. The final step in the grading process, after these key points have been relocated, is to reshape the perimeter of the piece between these grade points based upon the original shape of the model size and the operator's experience. During the reshaping process it is often necessary to introduce additional grade points to attain the desired final curve.

In recent years, grading systems have been evolved which assists the grader in the mechanics of grading, for example see U.S. patent 3,887,903 and the references cited therein. However, even with these computerised systems, the values for relocation of each of the grading points have to be designated by an operator and the grading of every new pattern style requires the expertise of a skilled grader. Also pattern pieces are treated as individual components of the assembly and as such at no time in the grading process are they related to each other so as to provide a convenient means of ascertaining their relationship or growth influence on each other. Any check of this sort has to be performed manually after the grading is completed with any required grading alterations performed during a second "pass".

Hence, present grading systems are limited by their need for a highly skilled operator to "initialize the computer's information file" for each new pattern style; and by the lack of association of the pattern pieces with the associated portion of the body form.

An object of the present invention is substantially to avoid the above described problems and discrepancies with prior art grading systems by providing correlation between the pattern piece to be graded and the portion of a body form associated therewith.

According to the invention, there is provided a method of grading a pattern piece which constitutes one of a number of differing pieces which together form a complete pattern which fits a body form of specified size, said method employing a programmed electronic computer which has stored therein growth data indicative of the change in relative locations of respective corresponding points between the body form of the specified size and the same body form of a different size, wherein said method comprises:

(a) applying to the computer data definitive of the geometry of a pattern piece for the body form of specified size;

(b) applying to the computer correlation data which identifies points on said pattern piece with points on a sketch of the body form, thereby to establish correlation between points on the body form with respective related points on the pattern piece; and

(c) causing the computer to respond to programmed instructions to modify the pattern piece geometry data in accordance with growth data selected as a function of the correlation data, so as to derive data which is definitive of the corresponding pattern piece for the body form of different size.

In one embodiment herein disclosed, the invention is performed by interaction of digitizer, computer and display unit. In the first part of the method, an operator places the basic pattern piece to be graded on the digitizing table and uses the digitizer to sequentially provide positional data as to the location of a plurality of points which define the geometry of the pattern piece. It is noted that the operator merely digitizes the piece by sequentially positioning a cursor to locations on the contour of the piece and that no judgment as to the repositioning of the points as they relate to graded pieces is involved. In response to this data from the digitizer, the computer controls the display unit so as to provide a real time graphical representation of the in-process pattern piece together with the digitized points on a display screen.

Next the operator positions a two-dimensional map (sketch) of the associated portion of the body, i.e. the body form, on the digitizing table and responds to requests from the computer as to the correspondence between the displayed pattern piece and the two-dimensional map of the corresponding body portion. In the disclosed embodiment, these requests are made by the computer sequentially placing the intersection of orthogonal crosshairs on each of the operator identified Inquiry Points on the display. The operator responds to the computer's inquiries by using the digitizer to provide the relative location of the corresponding key points on the two-dimensional sketch of the associated body portion.

A basic information file in the computer contains data which defines the basic growth and fullness data for all size ranges (for a given manufacturer) and this information is used to compute the relocation of the mesh of key points which define the body forms corresponding to the various sizes. From these two sets of data, i.e. the relationship of the pattern piece to the two-dimensional sketch of the body and the data file which defines the change in body dimensions between sizes, the computer produces grade rules for each of the grade points. From these grade rules and the basic digitized pattern piece the computer produces graded pattern pieces for the various sizes.

Special provisions are made for pattern pieces or portions thereof which do not grade in accordance with the changes in dimensions of the associated body portions, e.g. some cost pockets and items like lapels which require special grading rules. Means are provided for identifying these points which require special treatment during the digitizing of the pattern piece.

The improvements resulting from the present invention are graphically summarized in FIGS. 2A and 2B wherein FIG. 2B depicts the prior art point grade process and FIG. 2A an embodiment of the method in accordance with the present invention. In particular relative to FIG. 2B it should be noted that as illustrated by the steps 14, 16 and 18 of the prior art approach, there first must be established a set of grade rules which will cover all grade points for each size (step 14), the operator must select the proper one of these grade rules for each gradable point on the pattern (a judgment type decision is required) and the system merely follows the selected grade rule (step 18). By way of contrast, in carrying out the present invention, the operator only has to associate the model size to the sketch of the associated body portion as illustrated by step 20 in FIG. 2A—a routine type of operation which does not require the expertise of a skilled grader. The system automatically derives the grade (step 22) consistent with the designer's growth and fullness criteria which defines the movement of the mesh of key points on each of the body portions for the various sizes.

Further features and advantages of the invention will be better understood from the accompanying description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of a pattern grading system in accordance with one embodiment of the invention;

FIG. 2*a* illustrates some of the improved aspects of this embodiment of the

invention, as compared to the prior art approach shown in FIG. 2*b*:

FIG. 3 is a sketch of the upper portion of the body form and is utilized for establishing a relationship between the pattern piece being graded and the associated portion of the body;

FIGS. 4 and 5 illustrate the type of measurements required for each size to be graded;

FIG. 6 depicts the relationship between the pattern piece to be graded, the sketch of FIG. 3 and the associated portion of the body;

FIG. 7 is a perspective view of the digitizer shown in FIG. 1 with a typical pattern piece and the sketch of FIG. 3 shown thereon;

FIG. 8 shows a representation of a digitized pattern piece as it would appear on graphic display 26;

FIG. 9 shows a graded stack of pattern pieces which are produced by the system of this embodiment of the invention;

FIG. 10 is a flow chart of the DIGITIZING program for computer 24 of FIG. 1;

FIGS. 11 and 12 are flow charts of the GRADING program for computer 24;

FIGS. 13 through 16 are flow charts of the SKETCH MAINTENANCE program for computer 24;

FIG. 17 is a diagram useful for explaining the curve grading approach utilized by the subject system.

Referring first primarily to FIG. 1, the pattern grading system includes a computer 24 programmed for interacting with a digitizer 22 and a graphic terminal 26. Bulk data storage is provided by disk unit 28 and magnetic tape assembly 30. A typewriter terminal 32 is utilized for startup-shutdown operations and for system (program and data files) maintenance. A plotter 34 operates under the control of the computer 24 to provide the graded pattern pieces.

Computer 24, disk unit 28 and magnetic tape assembly 30 may be Models 1200, 4046/7 and 4030, respectively, marketed by Data General Corporation of Southboro, Massachusetts, U.S.A. Typewriter terminal 32 may be a Model 733 manufactured by Texas Instruments Corporation; and plotter 34 may be a Model DP—7 marketed by the Houston Corporation of Bellaire, Texas, U.S.A. Digitizer 22 may be a Model RSS—4DP/S—P marketed by the H. Dell Foster Company of San Antonio, Texas, U.S.A. and graphic terminal 26 could be Model 1201 manufactured by our Industrial Products Division at Oceanside, California, U.S.A.

The digitizer 22 includes a vertical bar 36 which is movable along parallel guide rails located at the top and bottom of a table 38. A cursor control box 40 is attached to bar 38 and includes a cursor aperture member 42 which is used to designate the points to be digitized. The cursor control box 40 and the cursor aperture member 42 are movable vertically along the bar 36 so that any point lying within the confines of table 38 may be digitized by the system. A multi-key function box 44 is also provided (see FIG. 7). By placing the cursor aperture member 42 over a desired point to be digitized and then actuating one of the five triggers on control box 40 or one of the eleven buttons on function box 44, electrical signals representative of the coordinates of the point under the cursor and the data word corresponding to the actuated key or button are applied to computer 24.

As will be explained in detail hereinafter, a pattern piece to be graded is correlated with a corresponding portion of a body form, and for this purpose a two-dimensional map or sketch of the body form, is utilized (see FIG. 6). As shown in FIG. 6 a pattern piece 43 is related to a two-dimensional map or sketch 45 of a body form 47 for which growth data is stored in the computer 24, such that the computer can guide the pattern piece in accordance with the derived growth data.

An example of sketch 45 for the upper portion of the body form is illustrated in more detail in FIG 3. The sketch of FIG. 3 can be visualized as a tailor's dummy reduced to a two-dimensional format. Producing the sketch from the dummy involves "graphically" splitting both sides of the torso and the length of the sleeve from the bottom of the armpit to the waist. One additional cut is made along the line at the top of the shoulder to the neck point.

As shown in FIG. 3, the above procedure produces a reasonably accurate two-dimensional map of the three dimensional dummy. However, it is noted that dimensional accuracy of the sketch is not required although it should be esthetically pleasing and recognizable to the ultimate users including junior level personnel in the design, production and planning operations of clothing manufacturers, for example.

Still referring primarily to FIG 3, a grid pattern is superimposed upon the

sketch of the body form so that lines thereof intersect at all of the more easily discernible points on the torso. For example, for portion 44 of the sketch, the horizontal lines represent lines along which the girth of the torso (x dimension) varies and the vertical lines (y dimension) are provided so that changes in the length of the torso may be indicated. It should be noted that the number of girth and length grid lines is a variable but that the number indicated on the sketch of FIG. 3 is believed adequate to grade the broadest variety of patterns for the major sectors of the clothing industry. The neck hole 41 is typical of a third group of points whose variations are treated as a change of perimeter, i.e. combining the effects of girth and length.

FIGS. 4 and 5 are illustrative of the type of measurements which would be specified by an apparel manufacturer for each of the sizes of interest, and such measurements define the relative position of each of the grid points, i.e. the intersection of a girth and vertical growth line.

DATA BASE

The data base for the system includes a table of measurements (TOM) which specifies how each of the body form measurements change between a preselected model size, such as a size 40 regular, and each of the other sizes of interest. For example, in going from a size 40 to a 42 in accordance with the body forms adopted by a given manufacturer, dimension 50 (see FIG. 5) might increase by 10/64 inches and dimension 52 by 8/64 inches. By way of example, a small segment of a printout of the table of measurements for typical sizes and variations thereof, i.e. long, extra long, short, etc. is presented herein as Appendix A.

The system data base also includes a relationship matrix (RM) which specifies how each of the grid points varies as a function of values in the table of measurements. For example, point C8 (see FIG. 5) which is defined by the intersection of horizontal line 8 and vertical line C, might grade in accordance with 30% of the value of the measurement table for measurement 50 and 25% of the value for measurement 52. Hence, point C8 would move by 3/64 to the left and 2/64 down when grading to a size 42. By way of example, a small segment of a printout of the relationship matrix is presented in Appendix B, wherein the "weight" column is the percentage factor, "+y" is up and "+x" is to the right.

It is noted that a table defining the movement of each grid point for each size could be utilized instead of the above described table of measurements and relationship matrix. However, the latter technique is preferred inasmuch as it reduces data storage requirements and perhaps more importantly it simplifies data handling for production alterations or variations.

OPERATION

The procedure for using the system of the invention will now be described. Following actuation of the system the following activity choice is provided by means of a display on the screen of graphic terminal 26.

SELECT ACTIVITY
SELECT DESIRED ACTIVITY CODE

1. INTRODUCE PATTERN PART
2. GRADE PATTERN PART
3. ASSIGN PATTERN PART
4. MAKE MARKER
5. RETRIEVE MARKER
6. SCAN LIBRARY
7. MODIFY LIBRARY

Only Items 1 and 2 of the foregoing list are constitute steps in the method of the invention; however, the other items are shown to demonstrate the "setting" in which the method of the invention might be incorporated. For example, Item 4 on the above activity selection list, i.e. Make Marker, relates to the process whereby

the graded pattern pieces for a given size are selectively arranged relative to one another to allow the maximum usage of the cloth goods.

Continuing with the description of the operation of the preferred system of the invention, the operator selects activity "1" by activating the key for numeral 1 on the keyboard of graphic terminal 26. In response to this selection a display consisting of the lefthand column of the below material is presented on the screen of graphic terminal 26.

INTRODUCE PATTERN PIECE
PIECE DEFINITION

PIECE ID	456789
PIECE DESCRIPTION	BACK
SYMMETRICAL? Φ—NO 1—YES	Φ
MIRRORED? Φ—NO 1—YES	1
GRADABLE? Φ—NO 1—YES	1

Next the operator uses the keyboard of the terminal to provide the information requested. For the illustrated example the piece to be graded has the arbitrarily assigned identificaion number of 456789; the piece is a "back"; it is not symmetrical, it is mirrored and it is gradable.

After the above discussed data has been supplied the computer next produces the following legend on the screen of graphit terminal 26.

"INTRODUCED PATTERN PIECE"
PIECE ORIENTATION

The instruction "Piece Orientation" as well as subsequent operating steps may be more clearly understood by concurrent reference to Table A hereinafter. After the model or sample pattern size, for example, size 40, is taped to the table of digitizer 22 the first step (of Sequence 1) is to place cursor 42 of the digitizer over one point towards the tail of the grain line 55 (see FIG. 7) and activate key 1 on control box 40. Next the cursor is placed above a point on the grain line which is towards the head thereof, and key 1 is again activated. The last two steps define the grain line orientation. Similarly steps 3 and 4 define the grow line 58, which in essence describes the X axis as it relates to the sketch, and key number 2 of control box 40 is used for this purpose.

Referring now to steps 5 through 8 of Table A, in some cases the primary grow line is only applicable to a portion of the pattern piece and to cover these situations steps 5 and 6 allows a section line to be defined and steps 7 and 8 provide data as to grow line "number 2" for the portion of the pattern to the right of section line.

Step N and N + 1 relate to providing information to the computer as to the size of the pattern piece so that the appropriate scale factor may be selected for the display of graphic terminal 26. This is accomplished by placing the cursor 42 to one corner of an imaginary rectangle encompassing the pattern piece on the board and activating key number 4; and then repeating the process for the opposite diagonal corner of the rectangle.

TABLE A

DIGITIZING PROCEDURES
SEQUENCE 1: PATTERN PIECE ORIENTATION FUNCTION

Step		Key
1	Grain Line Tail	1
2	Grain Line Head	1
3	Grow Line #1 Tail	2
4	Grow Line #1 Head	2
(5)	(Section Line #1 Tail)	3
(6)	(Section Line #1 Head)	3
(7)	(Grow Line #2 Tail)	2
(8)	(Grow Line #2 Head)	2
N	Extent Point #1	4
N+1	Extent Point #2	4
N+4	End Pass	R
	Abort	Φ

SEQUENCE 2: PATTERN PIECE INPUT FUNCTION

Step		Key
	Intermediate Point	1
	Break & Inquiry Point (VERTEX)	2
	Break & Inquiry Point (non-VERTEX)	3
	Beginning Shaper	4
	End Shaper	5
	Notch	6
	Pen Up	7
	Back Tab	8
	Back Space	9
	Abort	Φ
	End Pass	R

TABLE A — Continued

OPTIONAL SEQUENCE 2.5: FOR SYMMETRICAL PIECES ONLY
FUNCTION

Step		Key
1	Point on Line of Symmetry	1
2	End Pass	R
	Abort	Φ

SEQUENCE 3: SKETCH ORIENTATION
FUNCTION

Step		Key
1	Bottom Left Point	1
2	Bottom Right Point	1
3	Top Point	1
4	End Pass	R
	Abort	Φ

SEQUENCE 4: SKETCH INPUT
FUNCTION

	Key
Grade Point	1
Notch	2
(Lapel Peak)	
Skip	
Back Space	9
End Pass	R
Abort	Φ

The end of (Sequence 1) (PATTERN PIECE ORIENTATION) is implemented by key "R". An abort function is implemented whereby the operator may activate the key Φ to delete the previously entered data of Sequence 1.

It is noted that the most frequently used keys, i.e. 1 through 5 are implemented on both the control box 40 and the multi-key function box 44; while the less frequently utilized keys, i.e. 6 through 9, Φ and R are included only on multi-key function box 44 (see FIG. 7).

Upon the actuation of key R which designates the end of Sequence 1 (PATTERN PIECE ORIENTATION) the computer 24 automatically changes the legend displayed on the screen of graphic terminal 26 to:

"INTRODUCED PATTERN PIECE"
PIECE INPUT

In response to the above instruction the operator provides data to the computer 24 by means of the digitizer 22 which is definitive of the model pattern piece. For example, for the pattern piece shown in FIG. 7, the operator would

position cursor 42 over the point 56 and activate key number 2. As shown in Table A, in Sequence 2, key 2 signifies a break and inquiry point (VERTEX). In response to this operation the coordinate data for point 56 is applied to the computer as well as the data indicating that it is a "number 2" point i.e. a VERTEX point which does not require slope matching to adjacent points.

On the illustration of FIG. 7 the second point to be digitized is a "notch" which is designated by placing the cursor over the position of the notch 58 and activating key number 6. In the garment industry notches are used for lining up adjacent parts during the assembly of a garment.

Continuing with the digitizing of piece 43 of FIG. 7, point 60 might be digitized as a "break and inquiry point (non-VERTEX)" by placing the cursor over that point and activating key 3. In response to the non-VERTEX type break and inquiry point the computer is programmed to "slope" match the grade point with adjacent points. Points 62 through 65 are intermediate points which are implemented by the use of key 1 and these points shoud be sufficiently close together to adequately define the curve on which they lie.

In a similar manner the above described digitizing operation is continued with vertex type points being included at corners 66 and 68. Point 69 might be digitized with key 4 to indicate the beginning of a section that is to receive a "shaper" treatment and point 70 would be digitized by key 5 to indicate the end of the shaper segment. In between points 69 and 70 as many intermediate point (key 1) are included as requred. As will be described in greater detail hereinafter the shaper technique is a curve grading type procedure which inhibits the normal changes to curvature that results from proportional size grading. For example, as a pattern is graded up to larger sizes the normal grading procedures would result in a flattening of a curve. The shaper technique prevents this from happening and tends to hold the shape of the curve constant for the "shaper" segment.

As each grade point is digitized it is displayed on the screen of graphic terminal 26 (FIG. 1) and as the computer computes the curve between the most recent grade points, that segment is added to the display presentation.

The above described procedure is continued for the rest of the pattern until the key 2 type vertex point is digitized at point 71. Assuming that the section between points 71 and 56 is straight no further data would be required and the end of the Sequence would be indicated by actuation of key R.

Still referring primarily to Table A, Optional Sequence 2.5 is provided for symmetrical pieces. If during the initial data input step the pattern piece was specified to be symmetrical the computer will cause the below presented legend to appear on the screen of graphic terminal 26.

"PATTERN PIECE INPUT"
LINE OF SYMMETRY

In response to this request the operator digitizes two points on the symmetry line of the pattern piece by using key 1. It is noted that the piece shown in FIG. 7 is not symmetrical and consequently no line of symmetry is shown thereon.

Following Sequence 2 (or Sequence 2.5 if applicable) the computer causes the below legend to be displayed along with the representation of the digitized pattern piece.

"INPUT PATTERN PIECE"
SKETCH ORIENTATION

In response to the request "SKETCH ORIENTATION" the operator tapes sketch 45 (see FIGS. 3 and 7) to the table of digitizer 22 and places the cursor 42 above cross 72 at the lower lefthand corner of FIG. 3 and actuates trigger key 1 on control box 40. Next the operator repeats the just described cursor placement and trigger actuation for crosses 74 and 76. The direction of a line through points 72 and 74 provide the computer with information as to the horizontal (X) orientation of the sketch on the digitizer board and the direction of a line between points 72 and 76 provide information as to the vertical (Y) axis of the sketch. Also the distance between points 72 and 74 is indicative of the fact that the piece to be digitized is a coat and not a vest. The distance between points 72 and 76 define the piece further as a back portion of the coat. The sketch orientation Sequence terminates on the actuation of key R and in response thereto the presentation on the screen of graphic terminal 26 changes to that shown in FIG. 8.

It is noted that all of the grade points are illustrated on the display representation; however, in FIG. 8 only the grade points up to numeral 70 are shown for clarity of the presentation.

Computer 24 is programmed so that in the "Piece-Sketch Relationship" mode of FIG. 8, crosshairs 78 initially designate the first grade point, i.e. 56, which was digitized. In response to this display the operator indicates where point 56 is located on the sketch of FIG. 3 by placing the cursor 42 over the appropriate point of the sketch and activating the appropriate key in accordance with the descriptors listed in Table A for Sequence 4. For example, point 56 of the pattern piece shown in FIGS. 7 and 8 would be the lower righthand point on the back portion of the sketch of FIG. 3. After point 56 has been identified the crosshairs 78 will automatically be positioned to the next grade point, i.e. 58 and in response thereto the operator designates the corresponding point on the sketch of FIG. 3. This procedure continues, grade point by grade point, until all grade points have been correlated with the corresponding points on the sketch of FIG. 3 and this ends Activity "1", i.e. the introduction of the pattern part and its association with the corresponding portion of the body form.

The operator may then select "Activity 2" by activating the key for numeral 2 on the keyboard of graphic terminal 26. The computer than causes the lefthand column of the below presented format to appear on the screen of graphic terminal 26 and the operator uses the keyboard of the graphic terminal to provide the information requested. This operator provided information is then displayed in the righthand column.

GRADE PATTERN PIECE GRADE DEFINITION	
PATTERN PART ID	456789
LINE	XYZ
DESTINATION? ϕ—DISPLAY 1—PLOTTER	ϕ
STACK DESIRED? ϕ—NO 1—YES	1
START SIZE	36
STOP SIZE	44
STEP SIZE	2
VARIATION	R
PROD ALT ϕ—NO 1—YES	ϕ

For example, for the hereinabove described pattern piece, the identification number was selected as 456789. The "LINE" item "XYZ" defines the particular manufacturer and is indicative of the proper grading data file. Next a choice between "display" or "plotter" output is provided and the operator can select individual pattern piece outputs or a graded stack thereof. Also, the size range, the steps between sizes and the size variations (e.g. long, extra long, regular, etc.) and production alterations are specified. The production alteration option could be used if, for example, due to the use of heavy type material additional room in selected portions of the garment is desired.

A graded stack of five sizes is shown in FIG. 9 wherein the centre pattern might be the model size 40, the two larger sizes are 42 and 44 and the smaller pieces are sizes 38 and 36.

PROGRAM FLOW CHARTS

The complete program listing for accomplishment of the operations of the subject system on a Data General Corporation computer Model 1200 in ANSI FORTRAN Standard X3.9—1966 plus extensions computer language, is disclosed in our W. German Offenlegungsschrift No. 2556997 published 7th July 1977. However, in order to clearly document the theory of operation of the more important portions of the program, the following description will define several of the more important aspects of the program for operation of computer 24 of FIG. 1.

The computer program may conveniently be considered in three sections; the DIGITIZING PROCESSOR (ACT1); the GRADING PROCESSOR (ACT2) and the SKETCH MAINTENANCE PROCESSOR (SKETCH).

DIGITIZING PROCESSOR (ACT1)

The digitizing processor accepts identification and geometry data regarding the pattern part entered from the keyboard of graphic terminal 26 and digitizer 22 (FIG. 1). The processor performs curve fitting on digitized point data, transmits a variety of error and prompting messages to the operator and generates a disk-resident data file called the PART INGREDIENT FILE (PIF) which contains all information required by the system to describe the pattern part.

Referring now primarily to FIG. 10, the controlling or executive module (ACT1) of the digitizing processor performs the supervising functions of activating the proper processing modules to accomplish the tasks specified in the above paragraph. It is noted that as used herein the terms processor, module, program and subroutine all refer to some segment of instructions for the computer.

Upon start up of the system (see FIG. 10) module (P070) is called at 73 for initializing the display of graphic terminal 26.

PASS 1 module at 75 accepts and processes identifying information regarding the pattern part to be subsequently digitized. PASS 1 displays the digitizing setup menu on graphic terminal 26 which prompts the operator to supply the required information. The setup menu was discussed hereinabove relative to operational step "INTRODUCE PATTERN PIECE—PIECE DEFINITION", but for convenience of reference the menu is presented directly below.

INTRODUCE PATTERN PIECE
PIECE DEFINITION

PIECE ID	456789
PIECE DESCRIPTION	BACK
SYMMETRICAL? ϕ—NO 1—YES	1
MIRRORED? ϕ—NO 1—YES	1
GRADABLE? ϕ—NO 1—YES	1

It will be recalled that the material in the left-hand column of the above menu is automatically presented on the display of graphic terminal 26 and the information in the righthand column is provided by the operator. In particular with regard to the above setup menu, the "PIECE ID" is accepted from the keyboard and rejected if found to already exist within the system. The PASS 1 module then accepts the piece description as well as information concerning mirror (that is whether the subject pattern part has both a left and a right side) and symmetry status. If the operator indicates the pattern part to be nongradable, the PASS 1 module displays an additional menu calling for the operator to identify the components (e.g. coat, vest, etc.) to which the pattern part is to be associated.

The ORIENT module at 77 accepts and processes directional information

from digitizer 22 as a means of establishing reference with processor defined coordinate systems. The ORIENT module indicates to the operator that the orientation of the piece is to be entered by displaying the message "INTRODUCE PATTERN PIECE—PIECE ORIENTATION" and is implemented by the procedure outlined hereinabove when discussing Sequence 1 of Table A. To summarize Sequence 1, the ORIENT module accepts from the digitizer and processes information that describes the grain line, grow line and "extent" of the pattern part. The grain line is a vector describing the desired orientation of the part along the fabric which eventually is to be cut. The grow lines of the part is the vector or vectors describing the axis of the local coorinates system to which relative growth data will eventually be applied. Extent information, steps N and N+1 of Sequence 1, defines the size of the pattern part to be digitized in order that the proper scale and offset can be computed and subsequently used in transforming the digitized information to a displayable format. It will be recalled that the just mentioned steps define an imaginary rectangle which encompasses the pattern piece as it is oriented on digitizer board 22. The positional data from digitizer 22 is referenced to the coordinate system of digitizer Table 38 and ORIENT module 77 includes the data processing which selects the scale factor for the display data so that the "rectangle" is not larger than the viewing screen area of graphic display 26. Also, module 77 offsets the data for display purposes such that the center of a diagonal of the "rectangle" is at the approximate center of the viewing screen of graphic display 26.

The PASS 2 module (subroutine) is called at 79 and it inputs and processes information from the digitizer regarding the geometry of the subject pattern part. This information is applied during the above described "INTRODUCED PATTERN PIECE—PIECE INPUT" operational step and is implemented during Sequence 2 of Table A.

Still referring primarily to FIG. 10, at 80 a check is made whether the pattern piece had been specified as symmetrical during "INTRODUCED PATTERN PIECE—PIECE DEFINITION", see PASS 1. If the piece is symmetrical, PASS 5 is called at 82 and it requests the input data of Sequence 2.5 of Table A. PASS 5 processes the information regarding the segment of symmetry, which is provided by the operator via digitizer 22. The PASS 5 module accepts input data from the digitizer until a point is found to be within 1/5th of an inch of an existing line segment describing the perimeter of the pattern part.

At 84 a check is made as to whether the pattern piece had been specified as gradable by the operator during the data input phase of PASS 1. If the piece is not gradable module NOGRD is called at 86 and it provides PART INGREDIENT FILE (PIF) data for those pattern pieces which do not grade.

A PASS 3 module, called at 88, inputs and processes the identification or registration marks (see 72, 74 and 76 of FIG. 3) of the sketch. The procedure whereby the operator uses digitizer 22 to provide the information required by the PASS 3 module was discussed hereinabove relative to Sequence 3 of Table A. The various disk-resident sketch data files are then searched in an attempt to find the registration triplets that fall within acceptable tolerances of the digitized point data. If no triplet can be found an error message is displayed to the operator. If such a triplet is found, the required sketch data file is maintained in the processor memory for subsequent use during PASS 4.

The PASS 4 module is called at 90 and it inputs and processes pattern parts/sketch relationship information which is supplied from digitizer 22 during the operations of Sequence 4 of Table A. It will be recalled that during this operation the PASS 4 module sequentially positions crosshair 78 (see FIG. 8) to each of the grade points which were digitized during Sequence 2 and that in response thereto the operator uses digitizer 22 to identify the corresponding points on the sketch of FIG. 3.

The CRTPF module is called at 92 and it creates the PART INGREDIENT FILE (PIF) for the particular pattern part upon completion of the digitizing input.

The U010PIF module called at 94 writes the PART INGREDIENT FILE (PIF) into disk memory 26 (see FIG. 1); and the digitizing processor (ACT1) exists at 96.

GRADING PROCESSOR (ACT2)

The grading processor (program) is used to grade one pattern part to a specific size (or sizes in the case of a request for stacks) and variation for display, plotting or marker making. The controlling or executive module (ACT2) of the grading

processor performs the supervising function of activating the proper processing modules (subroutines) to accomplish the just specified task.

Referring now primarily to FIG. 11, module GDMEN is called at 100 and this module accepts and processes identifying information regarding the pattern part to be graded. Also, the GDMEN module causes graphic terminal 16 to display the grading processor setup menu which prompts the operator to supply the required information. This setup menu was discussed hereinabove relative to operational step "GRADE PATTERN PIECE—GRADE DEFINITION" but for convenience of reference it is presented below.

GRADE PATTERN PIECE
GRADE DEFINITION

PATTERN PART ID	456789
LINE	XYZ
DESTINATION? ϕ—DISPLAY 1—PLOTTER	ϕ
STACK DESIRED? ϕ—NO 1—YES	1
START SIZE	36
STOP SIZE	44
STEP SIZE	2
VARIATION	R
PROD ALT ϕ—NO 1—YES	ϕ

Module STKPT is called at 102 and this subroutine reads from disc memory 28 (FIG. 1) the file of points used as a reference for the "stack" or "nesting" processing. The stacking point is characterized as a reference mark common to all sizes of a pattern part which when graded pattern parts are piled one over the other and pinned at this point the parts shall nest in such a manner as to show the distribution of growth of the pattern with respect to all other sizes of the set, and especially to the model size. It should be noted that the reference of stacking point does not always lie on the pattern part itself and in the case of body grade is specified as one of the grid intersections in the basic body sketch. For the pattern piece stack of FIG. 9, stack point 104 was selected as a point of the center line of the back portion of the body sketch at a place which does not "grow", i.e. move between sizes. However, for other pieces the stack point may be more conveniently selected in the interior of or off of the pattern piece.

Still referring primarily to FIG. 11, at 106 the decision is made as to whether or not the piece is to be displayed on graphic terminal 26 (FIG. 1). This decision was specified by the operator in response to the "DESTINATION" question of the "GRADE PATTERN PIECE—GRADE DEFINITION" operational step. If the piece is to be displayed, module P045 is called at 108 for initializing the display.

Next module U101PIF is called at 110 and this subroutine reads the PART INGREDIENT FILE (PIF) from disc memory 28 (FIG. 1). The Part Ingredient File contains all of the data derived during the digitizing process (ACT1) of the sample pattern size, e.g. the positions of all gradable points, the curves connecting them and the grading algorithm to be applied to each.

Module STKPT is recalled at 112 and this subroutine now gets the stack point for the particular pattern piece to be graded. For example, since the piece being graded had been identified as a back portion of the coat during the above described operation of Sequence 3 of Table A, i.e. during Sketch Orientation, the

corresponding stack point is selected from the file retrieved at 102.

Still referring primarily to FIG. 11, at 114 module P015GTRM reads the grade tables (see Appendix A and B) for the particular manufacturer, e.g. manufacturer XYX, from disc memory 28 (FIG. 1); and at 116 module PRODA initializes the applicable production alterations as specified by the operator during the "GRADE PATTERN PIECE—GRADE DEFINITION" operational step.

Module C060G is called at 118 and this subroutine utilizes the above described retrieved data to grade the pattern piece. Subroutine C060G is described below relative to the flow chart of FIG. 12.

At 120 a decision is made whether the graded pattern piece is to be plotted or displayed on graphic terminal 26 (FIG. 1). If the graded piece is to be plotted then module Q044P is called at 122. If the pattern piece is to be displayed on graphic terminal 26 then module Q150D is called at 124.

At 126 the decision is checked as to whether more sizes are to be graded. If the answer is yes then ACT2 is re-entered at 110. If all the specified sizes had been graded then the program is re-entered at B1 whereby the setup menu is displayed at 110 in preparation for grading the next pattern piece.

Reference is now primarily directed to the flow chart of grade module (subroutine) C060G (118 of FIG. 11) which is diagrammed in FIG. 12. The output of this grade module is a graded part file item with all points and curves necessary to describe the graded part in the requested size and variation for plotting, display or marker making.

First it is decided at 128 whether the piece was specified as gradable by the operator-supplied data given during the "INTRODUCE PATTERN PIECE—PIECE DEFINITION" operational step.

At 130 the piece file (see subroutine U010PIF at 110 of FIG. 11) is searched to determine if special "C" points are involved. A "C" point is defined as a point which grades only in the "X" direction for changes in size and does not grade for changes in variation. Such a point occur at the waist line on the side body, for example. When "C" points exist on a part, the grading is done twice, once for size and once for variation. After the points and curves are graded for size, the Y positions of the "C" points are reset and all points except "C" point are graded for variation.

Point grade for size only is performed by module (subroutine) GRIDL at 132; curve grade is performed by module CVGRD called at 134 and point grade for variation only is implemented by subroutine GRIDL called at 136. Point grade for production alterations is implemented by module GRPAL called at 138.

At 140 the decision is made as to whether the section of the piece being graded is a lapel. The information to make this decision is available from the designation of the piece supplied during the sketch orientation operations, see Sequence 3 of Table A.

Lapel grading is accomplished after the points are graded but before curve grading by subroutine LAPEL called at 142.

A measurement of the change in perimeter of that portion of the front of the neck hole associated with a lapel is inculded in the table of measurement (TOM). The perimeter of the section of the upper portion of the lapel (usually starting at the lapel peak) is extended in accordance with this measurement. By utilizing the "shaper treatment" which is described hereinafter the change in perimeter occurs by extending that portion of the pattern which lies along the neck hole, in the vicinity of the shoulder. This entire section of the lapel is then rotated according to this measurement and this section is then rotated until it hits a line parallel to the break line and a constant distance from it. The curves are then graded to fit this new position.

Still referring primarily to FIG 12, curve grading is implemented by subroutine CVGRD called at 144; and at 146 it is decided whether the piece being graded has notches as indicated by the data provided during Sequence 4 of Table A. If the pattern piece being graded does have perimeter notches they are graded by subroutine PNOT called 148. Grow line notches are graded by subroutine G101GLNOT called at 150.

With the exception of nongradable parts and parts containing "C" points or lapel points, grading takes place in four steps: point grading, curve grading, notch grading, and part orientation. The point grading subroutines change the positions of all gradable points using the algorithm specified for each in the PART INGREDIENTS FILE (PIF) and the associated data in the grading tables for the specified size and variation. The curve grading subroutine, CVGRD, rotates and

proportions the curves to fit between the new point positions. Notch grading subroutines called at 148 and 150, recompute the positions of the notches on the new curves.

Following the grading of grow line notches at 150 a check is made at 152 as to whether the pattern piece is a facing. This information was supplied during the Sketch Orientation operation (Sequence 3 of Table A). If the piece is a facing then the proper rotation is applied by subroutine GFACE called at 154 and the graded piece file is set up at 156 by subroutine GPFST. This latter subroutine flips and/or rotates the graded information so as to align the stripe line with the requested orientation and sets up the graded part file item with the part oriented and absolutely positioned for a stack or a marker display or plot.

It is noted that at decision point 130 if no special "C" points were involved the routine branches to GRIDL called at 131 (lower right-hand corner of FIG. 12) whereby point grading for size and variation are performed. After subroutine 131 the operation is returned to D1 for point grading of production alterations at 138.

Still considering the grading subroutines of FIG. 12, normal point grading, e.g. subroutine GRIDL called at 132, implements the following equations:

1. For a normal point,

$$Px = (Mx) * (\cos\theta) - (My) * (\sin\theta)$$

$$Py = (Mx) * (\sin\theta) + (My) * (\cos\theta)$$

where Px, Py are graded point movement; Mx, My are key point movement; θ is the grow line angle of the associated grow line.

2. For a type "B" point,

$$Px = (Mx) * (\cos\theta) + (My) * (\cos\Phi)$$

$$Py = (Mx) * (\sin\theta) + (My) * (\sin\Phi)$$

where Φ is the stripe line angle.

3. For a projection point,

$$Px = Mx$$

$$Py = (Mx) * (\text{Tan } \theta) + (My) * (\sin\Phi)$$

4. For a "C" point,

$$Px = (Mx) * (\cos\theta) - (My) * (\sin\theta)$$

$$Px = 0$$

The information as to what type a given point is to be treated is contained in the data base for the body sketches.

Point grading for production alterations, i.e. subroutine GRPAL called at 138, is accomplished by using a set of tables which define the size and type of alterations to be made. As noted above production alterations are the type of changes necessitated by the material to be used with the pattern piece. For example, if canvas material is selected additional room is required in certain areas, such as the shoulders. Hence, the table which contain the list of measurement numbers and the measurement change associated with each is scanned by the last mentioned subroutine and any point which is affected by any measurement number in the list is additionally graded using the given measurement change.

Curve grading of subroutine CVGRD (134, 144 of FIG. 12) is simplified by graphic terminal 26 (FIG. 1) which includes a generator that can produce conic curves in response to only four digital parameters. The operation of terminal 26 is described in detail in the system reference manual therefor copyrighted in USA in 1974 by our Industrial Products Division; Conographic Products, Carlsbad, California. Algorithms applicable for curve fitting point type data is given in Appendix D to the just cited manual and in U.S. patent 3,809,868. By using the

conographic generator of terminal 26 the subroutine PASS2 (79 of FIG. 10) curve fits digitized point data by generating four parameters (JKLM) for each curve section.

Curve grading subroutine CVGRD (FIG. 12) can grade the curve sections by the very simple procedure illustrated in FIG. 17. For example, if curve 160 is defined by the four parameters (JKLM) and connects point P_1P_2 of the model or master pattern and if points P_1 and P_2 grade to points P_1' and P_2' then the graded curve 162 may be expressed as d'/d(JKLM) where d and d' are the distances between point P_1 and P_2 and P_1' and P_2, respectively.

When the curve between two graded points is to remain a constant size and shape during curve grading that segment is designated as a "shaper". It will be recalled that keys 4 and 5 of Sequence 2 of Table A specifies the beginning and end, respectively, of the shaper segment during the process of digitizing the pattern piece. In accordance with such "shaper" grading, when the distances and direction between two points is changed as a result of point grading, the curves between the two points are separated into two sets, i.e. shaper curves and proportional curves. Both sets are rotated to accommodate the new point orientation but only the proportional curves are changed in size to fill the new dimension between the points. In the case where the distances between the points is such that the shaper curves will no longer fit between the points an error arises, the shaper set is graded to fit and the proportional set is deleted.

Still referring primarily to FIG. 12, notch grading (see subroutines called at 148 and 150) takes place after point and curve grading and the new position of the notch is given as a conographic curve and a position on the curve.

With respect to subroutine GPFST called at 156 in FIG. 12, when all information in the PIF file is graded or a part is nongradable, the graded part file item is produced by this subroutine. It orients and absolutely positions the part for a stack, display or plot. All points and curves are rotated until the stripe line of the part is horizontal or at the requested angle. All points are recomputed to put the beginning point of the perimeter at some requested point and a conographic curve is generated for each notch. The rectangular limits of the part are recomputed for the new orientation.

SKETCH MAINTENANCE PROGRAM

The sketch maintenance program (SKETCH) is designated to provide off-line information handling of those data bases which describe the structure and content of the various body sketches such as for example the one shown in FIG. 3. These are the sketches which are used in the pattern digitizing activity.

Flow charts of the sketch maintenance program are presented in FIGS. 13 through 16 to which reference is now primarily directed. The sketch maintenance program receives at 161 initializing information from teletypewriter 32 and in response thereto at 163 the requested sketch file is read from disc memory 28 (FIG. 1). It is noted that after the initializing request all subsequent commands including "END" originate from the multi-key function box 44 and/or digitizer 22. Feedback messages to the operator regarding redefined sketch layouts and error messages are via graphic display terminal 26.

Again referring to FIG. 13, at 163 the computer retrieves the operator requested sketch description data file from the disc unit 28 and at 164 program P180 is utilized for accepting three points from the digitizer which are used to orient and position the sketch as it resides on the digitizing Table 22, for example, see 72, 74, and 76 of FIG. 3. Display scaled factors are computed at 166 and subroutine DSPPT is called at 168 for the purpose of displaying in an oriented fashion the set of three points which define the position and orientation of the sketch on graphic terminal 26.

At 170 the decision is made as a function of the count of points contained in the requested file as to whether the sketch is new (a count of zero indicating a new sketch to be subsequently defined). If the sketch is not new then a validity check is made at 172 on the basis of the registration marks entered at 164, e.g. points 72, 74 and 76 of FIG. 3. If it is not a new sketch and the registration marks do not coincide with the marks already in the file an error message is caused to be displayed by subroutine 174 and the program is halted.

Subroutine DSPALP is called at 176 to display the following command menu.

(1) INSERT

(2) ENQUIRE

(3) DELETE

(4) POSITION

(5) END

At 178 it is again determined whether or not the sketch is a new sketch and if it is not then the points which define the particular sketch are displayed on graphic terminal 26 (FIG. 1) and program P180 is called at 182 for the purpose of interrogating the digitizer 22 (FIG. 1) for input command data. After filtering invalid key selections i.e. any key other than 1 through 5, at 184 then the processing of FIGS. 14 through 16 is performed.

Referring now primarily to FIG. 14 the command from the digitizer (or multi-key function box 44) is decoded at 186 and if the command is "END" the operation branches to B4 of FIG. 16 wherein the old file is deleted at 188 and a new file containing any and all insertions and deletions made during the session is created at 190.

Again referring primarily to FIG. 14 if the command from the digitizer was "INSERT, ENQUIRE, OR DELETE" (keys 1, 2 and 3 respectively) then it is determined at 196 if there exist a point in the sketch's data base which matches the input point.

If the command is "INSERT" as determined at 196 then the decision or flag resulting from operation 196 is checked at 200 and if a match does not exist then the operation branches to point A3 of FIG. 15. If the command is INSERT and there is already a data point for that sketch in that data base then the error message is caused to be displayed by the subroutine called at 202 and the program returns to point C1 of FIG. 13. If a match does not exist at 200 the operation continues to 204 of FIG. 15 where subroutine PO25 is called for the purpose of reading data of the following type: three characters, of which the first two are an alphabetic and a numeric identifying the point's position with regard to the torso mesh (e.g. C8 on FIG. 5), and a third numeric identifying the grade type of the subject point. If the data supplied by the key board is valid as check at 206 the sketch's data base is updated at 208. If the data is not valid then the error message subroutine is called at 210. Following the sketch data base updated at 208 the new point is displayed on the sketch in response to the subroutine called at 210 and the operation branches back to point C1 of FIG. 13.

Referring momentarily to FIG. 14, if at the decision point 198 the command was determined not to be "INSERT" then the program branches to point A4 of FIG. 16 whereas a check is made to see if a match between the new data position and an existing point in the data base exists. If a match does not exist the error routine is called at 216 to indicate an attempt is being made to delete or inquire about a nonexisting point; if a match does exist then the decision is made at 218 as to whether the command is "ENQUIRE" or not. If the command is "ENQUIRE" then subroutine DSPALP is called at 220 for the purpose of displaying the data of the type described above for the digitized ENQUIRY point. If the command at 218 is not "ENQUIRE" then it must be "DELETE" and the subroutine called at 222 displays the sketch modified so that the point corresponding to the input coordinates is deleted. At 224 the sketch data is updated by removing the data on the deleted point and rearranging the file so as to decrement all point pair counts to remove voids in the keypoint table.

To summarize the response of the sketch maintenance program to the five valid commands received by the digitizer:

if the command is "POSITION", the cursor of the display is directed to appear at the digitizer's crosshair equivalent position relative to the sketch;

if the command is "INSERT" and there exist no conflict with an already existing point, additional data regarding the grading characteristics of the newly defined point is accepted from the keyboard and the local sketch data file is updated;

if the command is "ENQUIRE" and there exist a previously defined point, the grid intersection designator and the point grade type are displayed to the operator;

if the command is "DELETE" and there exists a previously defined point, the

edited sketch is displayed and the local sketch data file is updated; and

if the command is "END" the previous sketch data file is deleted and the local sketch data file is created as the new disk-resident data file and the program then halts.

As previously mentioned, program listing for accomplishment of the operation of computer 24 of the system on a Data General Corporation computer Model 1200, in ANSI FORTRAN Standard X3.9—1966 plus extensions computer language, is set forth in our West German Offenlegungsschrift No. 2556997.

APPENDIX A

MEAS.#	32	33	34	35	36
1	−0.500	−0.437	−0.375	−0.312	−0.250
2	−1.000	−0.873	−0.750	−0.625	−0.500
3	−1.250	−1.093	−0.937	−0.781	−0.625
4	−1.250	−1.093	−0.937	−0.781	−0.625
5	−1.250	−1.093	−0.937	−0.781	−0.625
6	−1.500	−1.312	−1.125	−0.937	−0.750
7	−1.500	−1.312	−1.125	−0.937	−0.750
8	−1.500	−1.312	−1.125	−0.937	−0.750
9	−2.500	−2.187	−1.875	−1.562	−1.250
10	−1.500	−1.312	−1.125	−0.937	−0.750

APPENDIX A

MEAS. #	37	38	39	40	41
1	−0.187	−0.125	−0.062	0.000	0.062
2	−0.375	−0.250	−0.125	0.000	0.125
3	−0.468	−0.312	−0.156	0.000	0.156
4	−0.468	−0.312	−0.156	0.000	0.156
5	−0.468	−0.312	−0.156	0.000	0.156
6	−0.562	−0.375	−0.187	0.000	0.187
7	−0.562	−0.375	−0.187	0.000	0.187
8	−0.562	−0.375	−0.187	0.000	0.187
9	−0.937	−0.625	−0.312	0.000	0.312
10	−0.562	−0.375	−0.187	0.000	0.187

APPENDIX A

MEAS. #	42	43	44	45	46
1	0.125	0.187	0.250	0.312	0.375
2	0.250	0.375	0.500	0.625	0.750
3	0.312	0.468	0.625	0.781	0.937
4	0.312	0.468	0.625	0.781	0.937
5	0.312	0.468	0.625	0.781	0.937
6	0.375	0.562	0.750	0.937	1.125
7	0.375	0.562	0.750	0.937	1.125
8	0.375	0.562	0.750	0.937	1.125
9	0.625	0.937	1.250	1.562	1.875
10	0.375	0.562	0.750	0.937	1.125

APPENDIX A

MEAS. #	XS	S	R	L	XL
1	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.187	0.187
3	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000

APPENDIX B

KEY PT.	MEAS. #	WEIGHT
	X RELATIONS	
A.1	1	−1.000
A.2	1	−0.500
	2	−0.500
A.3	2	−1.000
A.4	30	−1.000
	12	0.670
	35	0.330
A.5	12	1.000
	15	1.000
	16	−1.000
	30	−1.000
A.6	12	1.000
	15	0.500
	16	−0.500
	30	−1.000
A.7	12	−1.000
	30	−1.000
A.8	30	−1.000
	35	1.000

APPENDIX B

KEY. PT.	MEAS. #	WEIGHT
	Y RELATIONS	
A.0	50	1.000
A.1	51	1.000
A.2	51	0.500
	52	0.500
A.3	52	1.000
A.4	61	0.670
	62	0.330
A.5	57	1.000
A.6	61	0.500
	57	0.500
A.7	61	1.000
A.8	62	1.000

WHAT WE CLAIM IS:—

1. A method of grading a pattern piece which constitutes one of a number of differing pieces which together form a complete pattern which fits a body form of specified size, said method employing a programmed electronic computer which has stored therein growth data indicative of the change in relative locations of respective corresponding points between the body form of the specified size and the same body form of a different size, wherein said method comprises:

(a) applying to the computer data definitive of the geometry of a pattern piece for the body form of specified size;

(b) applying to the computer correlation data which identifies points on said pattern piece with points on a sketch of the body form, thereby to establish correlation between points on the body form with respective related points on the pattern piece; and

(c) causing the computer to respond to programmed instructions to modify the pattern piece geometry data in accordance with growth data selected as a function of the correlation data, so as to derive data which is definitive of the corresponding pattern piece for the body form of different size.

2. The method of claim 1 wherein the step of feeding correlation data into the computer includes causing said computer to respond to its programmed instructions and to the pattern piece geometry data for controlling a display device in order to produce a display representative of said pattern piece and to sequentially identify different points on the display representation; manually operating a digitizer to sequentially identify locations on the sketch which correspond to sequentially identified points on the display representation: and applying the output signals from the digitizer to the computer.

3. The method of claim 1 wherein the step of feeding data definitive of the geometry of the specified pattern piece into the computer includes manually operating a digitizer to sequentially produce data defining points on the pattern piece for the specified size body form and applying the output signals from the digitizer to the computer.

4. A system for performing the method of Claim 1 comprising a programmed electronic computer which has stored therein said growth data as a function of the relative location of points on the sketch; a display unit controlled by said computer

for displaying a representation of the pattern piece; and a digitizer whose operation allows an operator to identify the location of the pattern piece on the sketch whereby the appropriate growth data is identified to the computer which uses it to produce the data for the corresponding pattern piece for the different size body form.

5. The system of claim 4 wherein said computer is programmed so that it requests and then accepts said pattern piece geometry data from the digitizers.

6. The system of claim 5 wherein said computer is programmed so that it requests and then accepts said correlation data from the digitizer.

7. The system of claim 5 and/or claim 6 wherein said computer is programmed so that said requests are displayed on said display unit.

8. The system of claim 6 wherein said computer is programmed so as to request said correlation data for each of a plurality of points by sequentially identifying points on the displayed representation of the pattern piece, and so as to respond to signals from the digitizer as definitive of locations on the body form which correspond to respective identified points on the pattern piece.

9. The system of claim 4 wherein the growth data stored in said computer include measurement tables which specify for each one of a plurality of sizes the change in a plurality of measurements of the body form between a given size and the specific size and matrix relationship tables which relate said measurement values to the position of points on said sketch.

10. The system of claim 5 wherein the digitizer includes means for designating segments of the geometry of the pattern piece as shaper segments and wherein said computer is programmed in response to said designation for refitting curves between adjacent points so that the shape of the curve within the portion designated as a shaper is held constant causing any necessary growth to occur in the unconstrained segments of the curve.

11. The system of claim 5 wherein, for a body form of the upper torso, said digitizer includes means for designating the lapel peak point; said growth data include a measurement of the change in perimeter of that portion of the front of the neck hole associated with the lapel; and said computer is programmed for grading the front portion of the neck hole associated with the lapel as a function of said stored growth data so that the change in perimeter occurs by extending that portion of the pattern which lies along the neck hole in the vicinity of the shoulder and for relocating the peak of the lapel by rotating the entire upper section of the lapel until it intercepts a line parallel to the breakline and a constant distance therefrom, and for reshaping the lapel from the peak to the lower break point.

12. The system of claim 4 further comprising a plotter which responds to computer output data so as to make a plot of said pattern piece for the different size body form.

13. A method of grading a pattern piece substantially as hereinbefore described with reference to the accompanying drawings.

14. A set of graded pattern pieces produced by the method claimed in any one of claims 1, 2, 3 or 13.

15. A system of grading pattern pieces substantially as hereinbefore described with reference to the accompanying drawings.

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1571290 COMPLETE SPECIFICATION

13 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

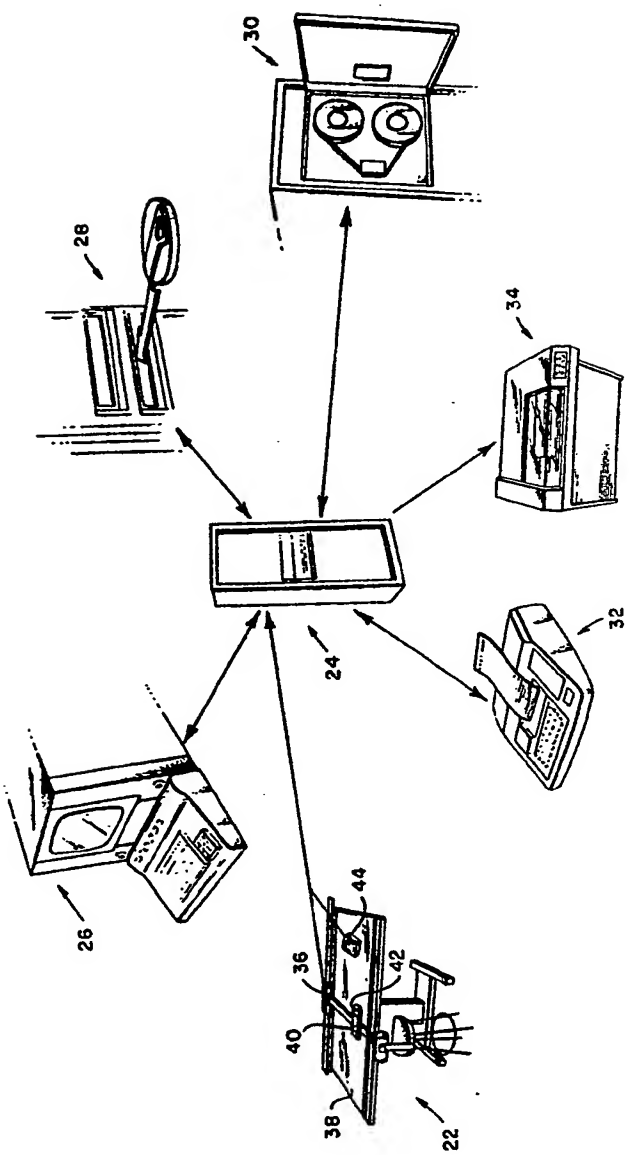


Fig. 1.

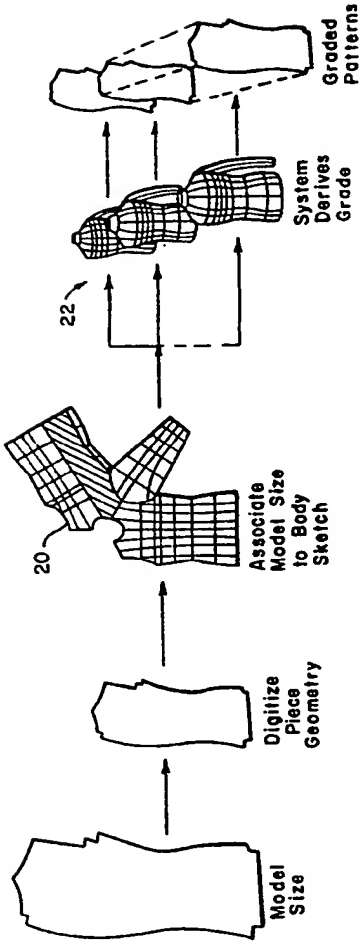


Fig. 2a

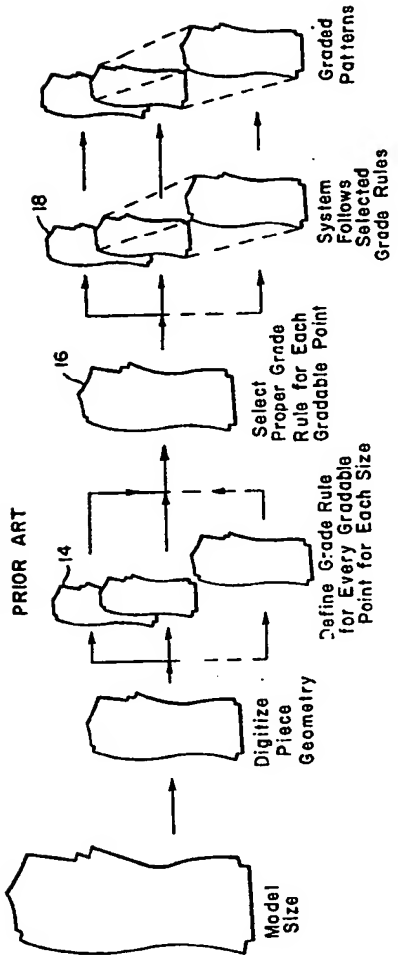
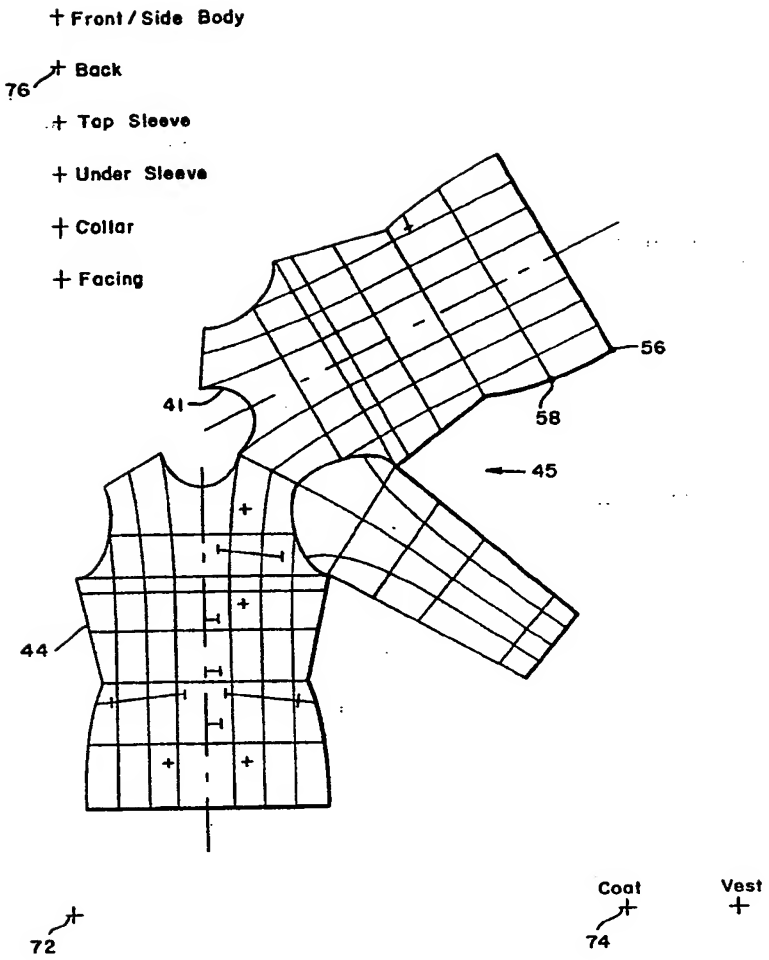


Fig. 2b.
PRIOR ART

Fig. 3.



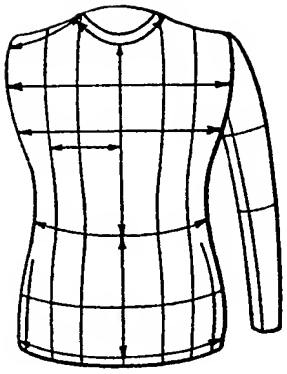


Fig. 4.

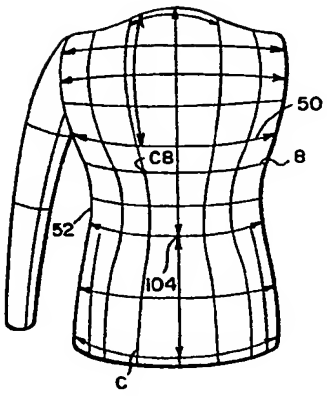


Fig. 5.

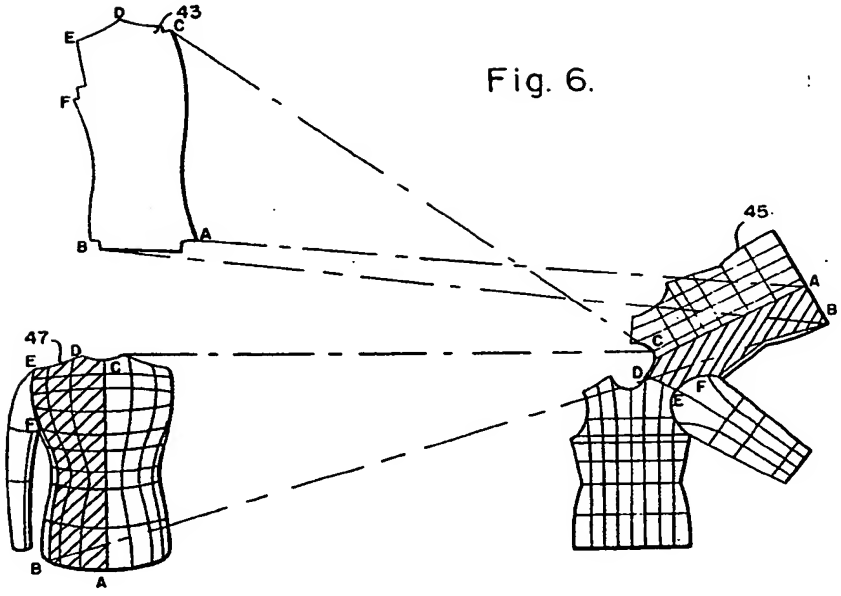


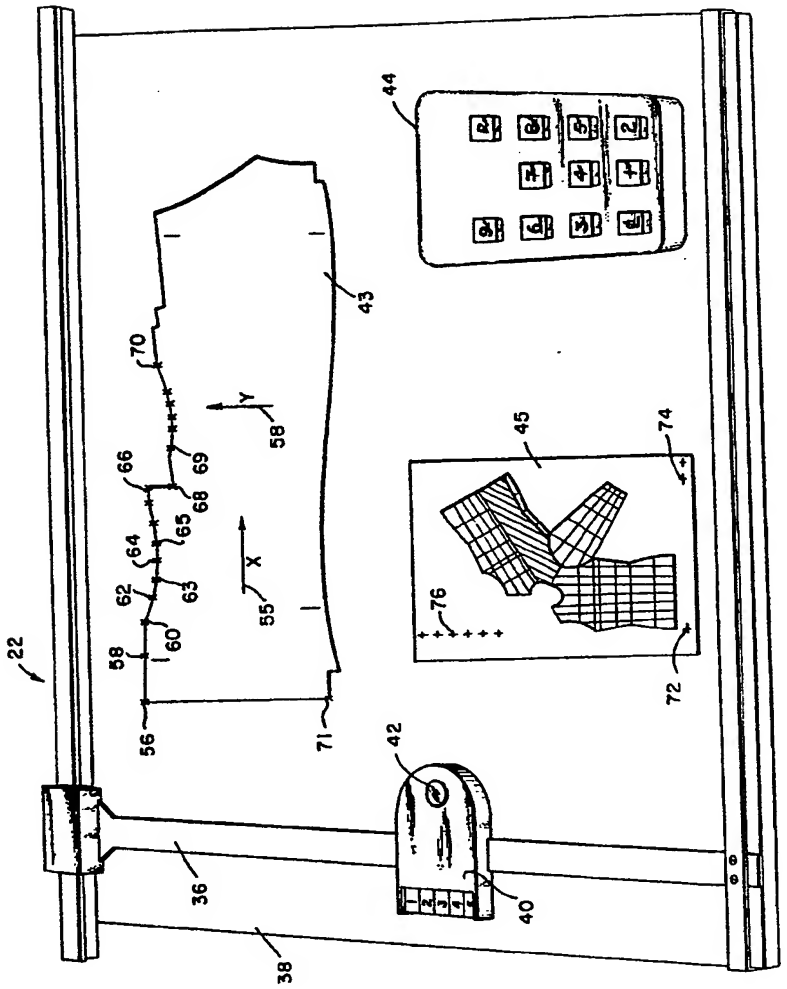
Fig. 6.

1571290 COMPLETE SPECIFICATION

13 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 5

Fig. 7



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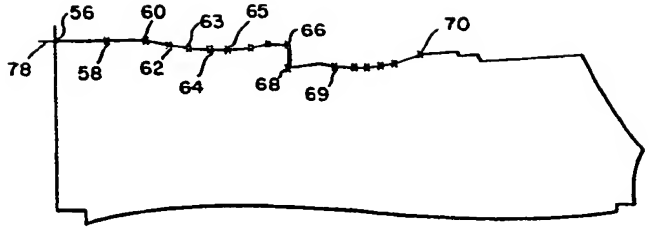

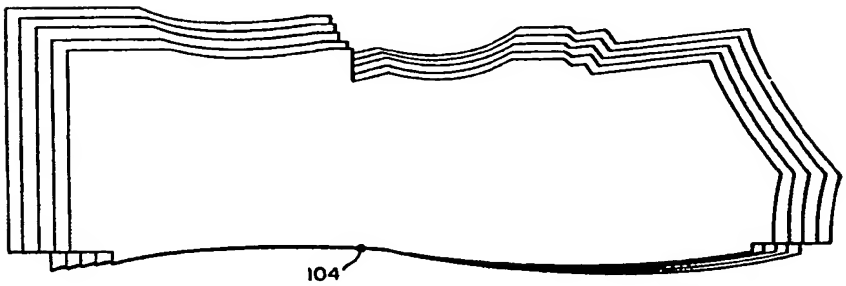

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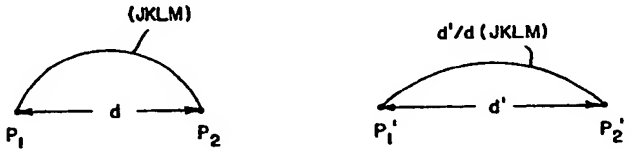
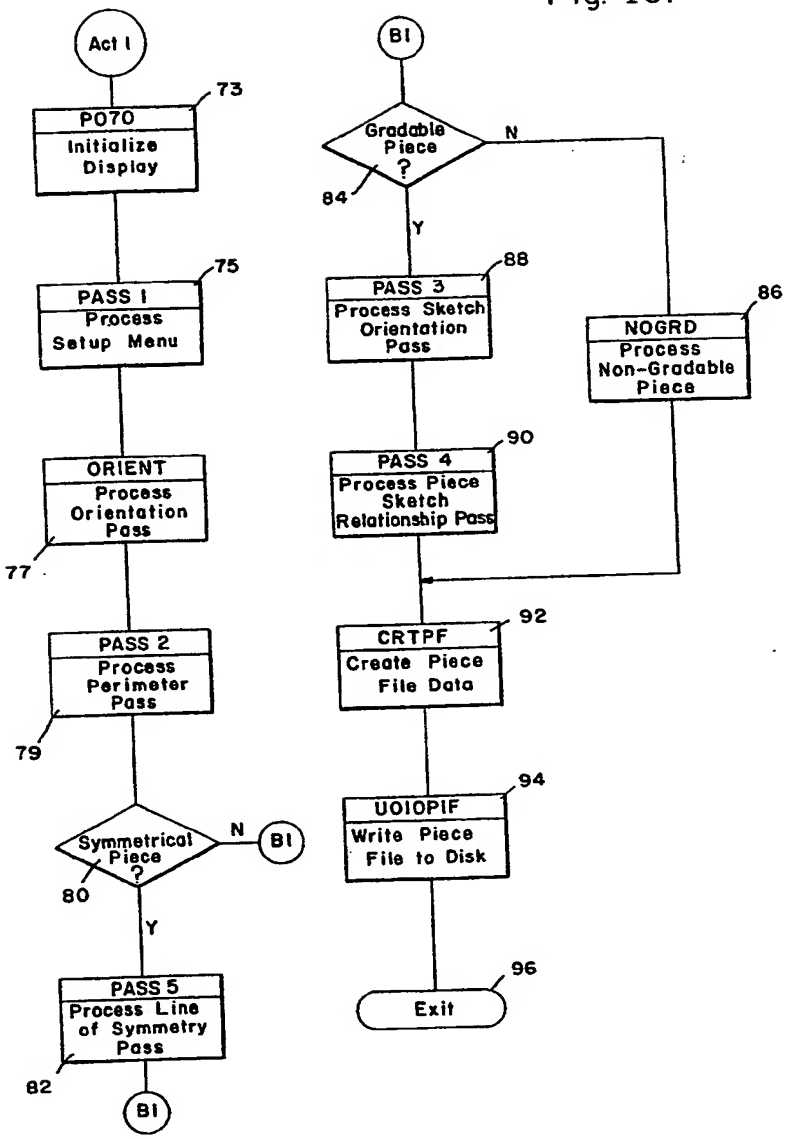


Fig. 17.

Fig. 10.



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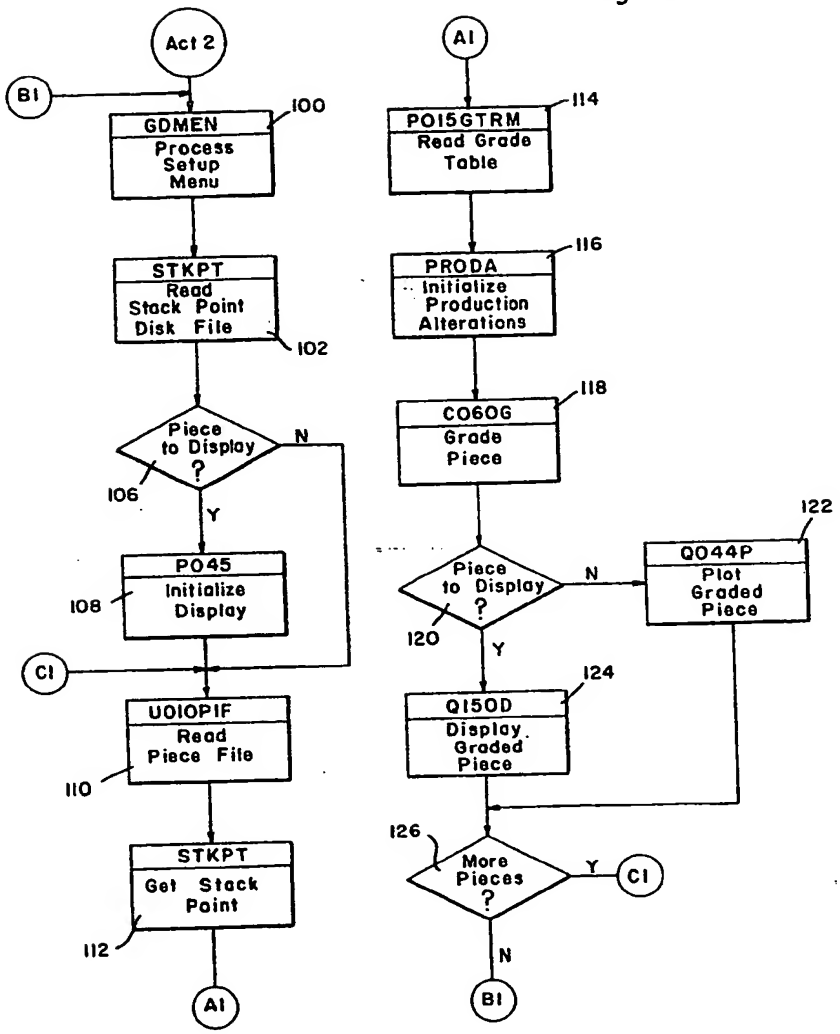

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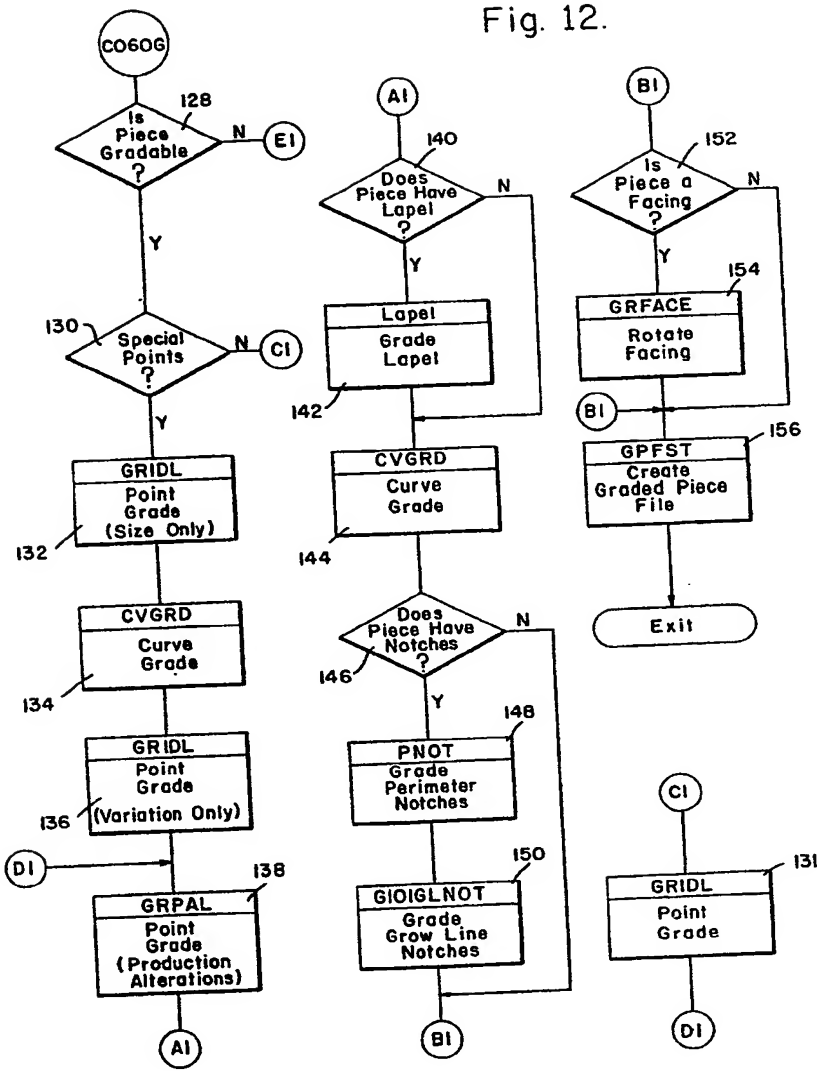
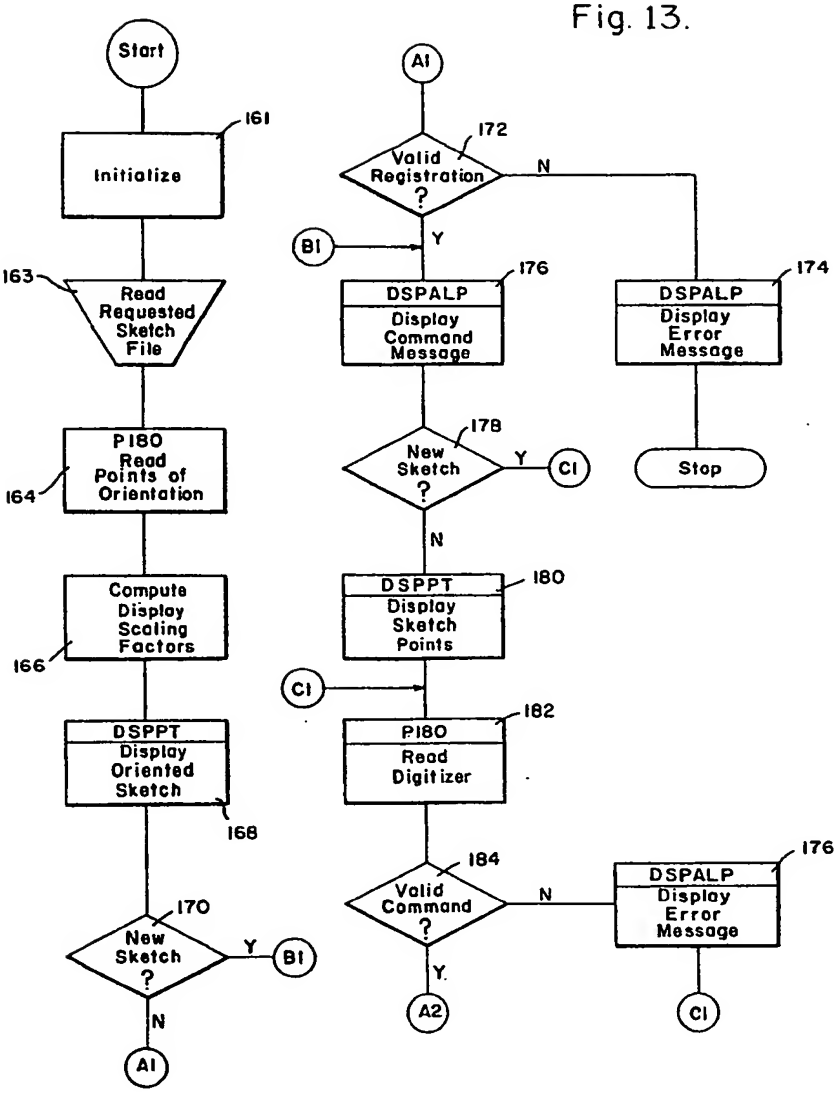


Fig. 13.



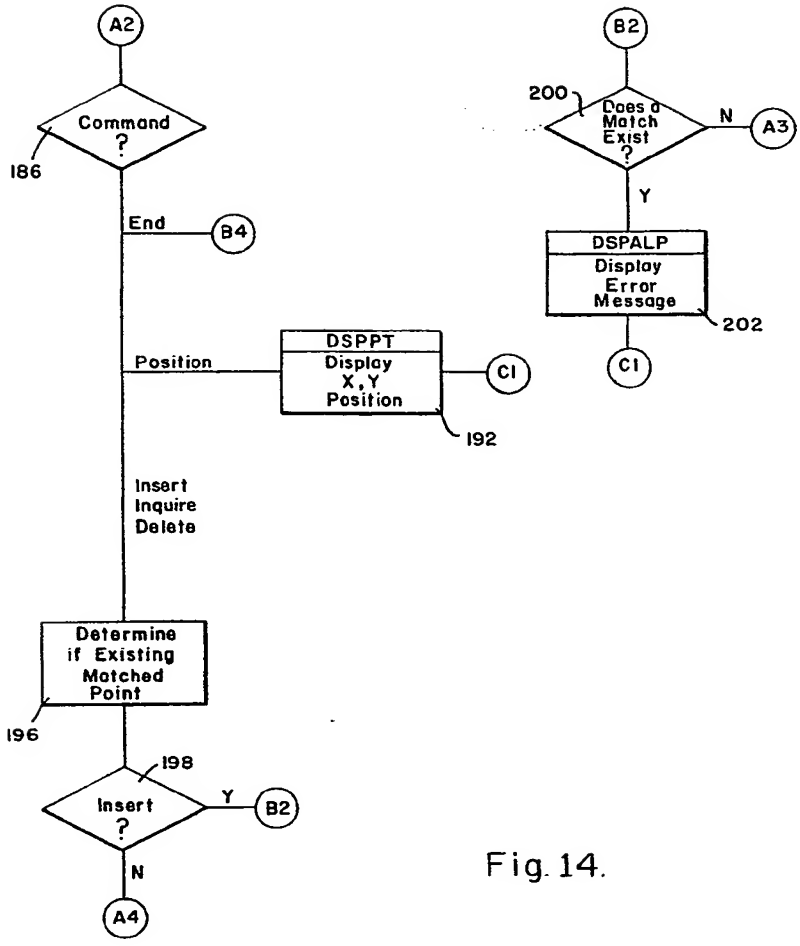
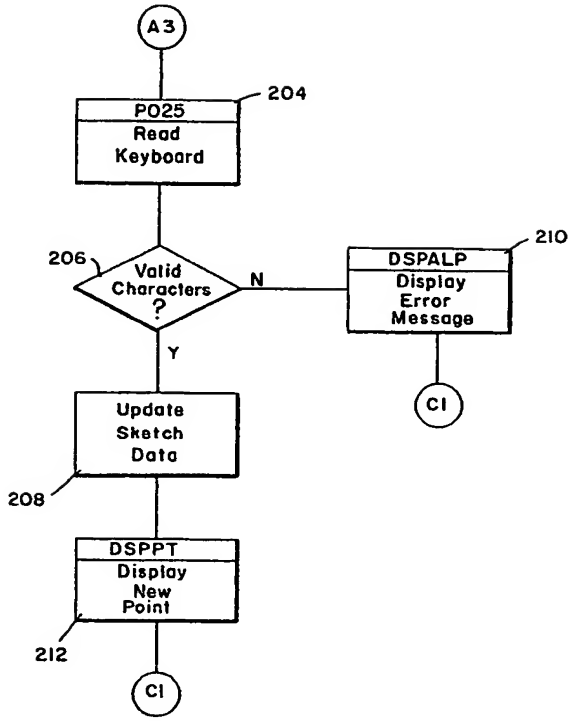


Fig. 14.

Fig. 15.



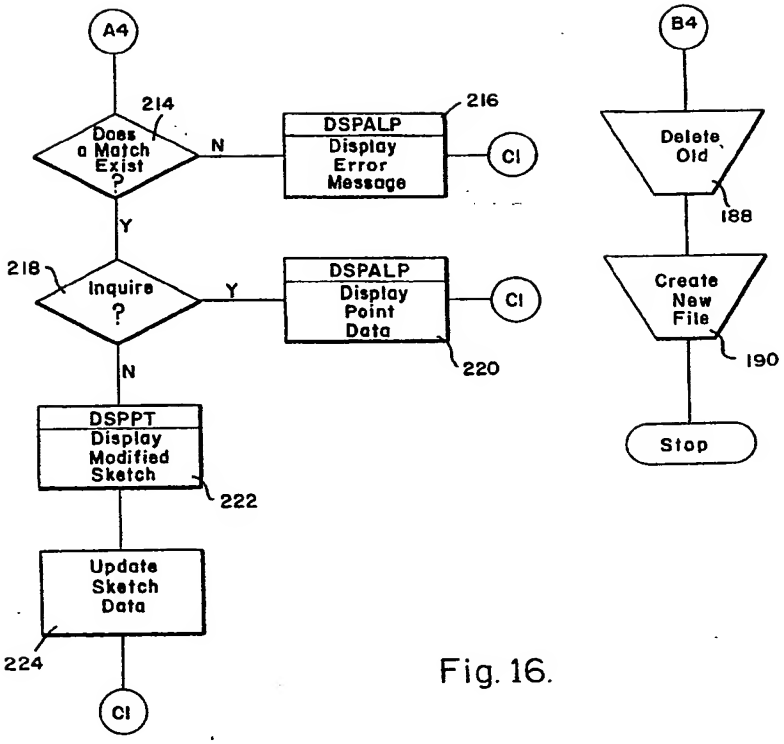


Fig. 16.